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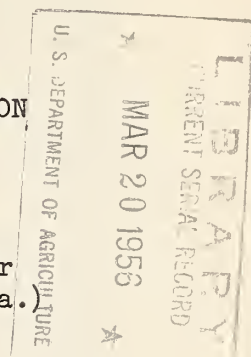
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UNITED STATES DEPARTMENT OF AGRICULTURE
Agricultural Marketing Service
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ACHIEVEMENT OF LIGHTING STANDARDS FOR THE GRADING OF COTTON

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meeting February 6-8, 1956, Biltmore Hotel, Atlanta, Ga.)



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Lighting Important to Cotton Classification

Cotton classification as practiced by several thousand men in this country is the art of describing the quality of cotton in terms of grade and staple length in accord with official standards. For grade, classification is based on appearance and is accomplished by visual inspection of the color, leaf, and preparation of a sample, with a mental integration by the classer of these three factors into a single grade description. This means that the quality and quantity of lighting in a cotton classing room becomes a matter of considerable economic importance, for not only are grade factors judged visually, but the length of staple also.

This season the United States Department of Agriculture already has classed twelve and a half million bales, over eleven and a half million of these for farmers under the Smith-Doxey Act which provides free classification and market news service for those organized in groups to promote the improvement of cotton. If lighting varies enough to make judgements off by even one-half of a grade, or by 1/32nd inch in staple length, it could make a very great dollar difference when

applied to the very large number of bales that are classed each year. For example, this year (1955 crop) the average grade and staple is about Strict Low Middling, 1-1/32 inch cotton. On a basis of 1955 loan differences applied to 500-pound bales, a half grade below this average would mean \$6.62 per bale; 1/32nd inch staple shorter would mean \$2.50 per bale. Multiplied by the millions of bales classed, this becomes millions of dollars!

There is also the problem in naturally daylighted rooms of expense for time lost in poor weather when there is a lack of sufficiently good classing light. This is a serious consideration, particularly during peak loads, for not only is classification delayed, and more help necessary to accomplish the same amount of classing in the fewer hours of good lighting, but space requirements are greater in order to take care of storage of samples that pile up during such periods.

This year two of our 35 classing offices classed over a million bales each and four others well over a half a million each. Whether such large-scale classing is done in a government or commercial office it becomes imperative to do everything possible that will help to keep classing on a continuous as well as on a uniform basis. Our investigations in the field of lighting have been made with this as our purpose.

Natural Daylight Skylights, 1914-1937

The United States Department of Agriculture has provided leadership in setting specifications for lighting cotton classing rooms for many years. As long ago as 1914 what is known as a Government-type skylight was first developed in connection with services under the Cotton Futures Act. The first slide (figure 1) illustrates a Washington classing room of this type. It was built in 1937 and illustrates the best development up to that time for lighting a classing room. Plans for this room and those that preceded it served many years as guides for builders and architects designing classing rooms. (In this country we seldom have calls for these plans today, but we still have requests from overseas.)

Artificial Daylighting Studies

In 1919, as far as we can determine, artificial daylighting was first tried out in our offices. With the cooperation of Norman Macbeth, Sr., a specialist in artificial daylighting, this early experiment was made in our New York office, and while it proved that cotton could be classed under artificial light of satisfactory daylight quality, it was unsuccessful chiefly because daylight lamps of those days were awkward and uncomfortable to use when placed in position to provide a sufficient quantity of light. The classer needed more freedom to move about with his sample.



Figure 1.

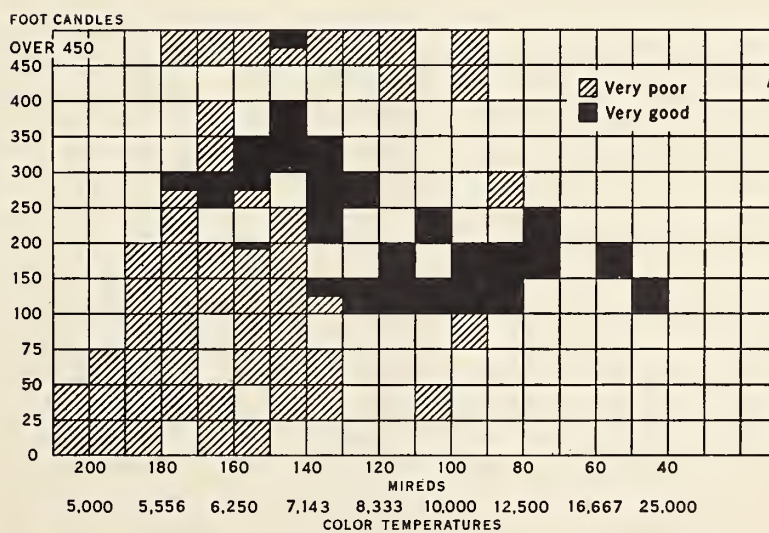


Fig. 2 -Footcandle and color temperature data taken at selected color matching stations in four large textile mills. Conditions for color matching called very good shown against those called very poor.

The next step came in the early 1930's when, in connection with studies of natural daylighting of classing rooms, a survey was made of the amount and distribution of light in all of all USDA's larger classing rooms. This was basic information, needed before any serious attempt could be made to provide specifications for lighting either large or small areas with artificial daylighting. The results, shown in the next slide (tables 1 and 2), clearly indicate that amount of

TABLE 1.—Average of Maximum and Minimum Illumination in Footcandles Read Hourly over 30-day Periods in June and December, Using a Weston Photocell Meter for Certain Sky and Classing Conditions (For Horizontal Plane).

Classing conditions	Sky conditions					
	Clear		Slightly cloudy		Overcast	
	June	December	ne	December	June	December
Very good	108-150	41-50	126-155	52-65	100-150	115-150
Good	118-145	51-60	147-174	64-77	204-252	116-122
Fair	109-149	37-48	138-158	65-75	137-160	80-91
Poor	119-148	31-36	140-168	65-74	99-118	61-70

TABLE 2.—Average of Maximum and Minimum Illumination in Footcandles for Classing Designated as "Good"

Classing room (location)	Weather conditions					
	Clear		Slightly cloudy		Overcast	
	June	December	June	December	June	December
Washington (new bldg.)	180-190	34-45	220-235	45-55	220-250	.....
Washington (old bldg.)	120-140	40-50	200-230	65-75	250-275	55-65
Austin	120-150	80-90	130-160	150-160	270-310	175-190
Memphis ¹	85-100	55-60	110-120	50-60	.....	.....
Memphis ²	140-240	80-105	220-295	70-100	200-250	.....
Houston	130-140	50-60	140-150	75-85	150-160	.....
Charleston	130-150	45-55	110-115	50-60	250-350	140-150
Atlanta	60-70	75	130-140	60-75	.....	90
Savannah	130-150	.....	140-150	60-70	.....	.....
New Orleans	70-90	12-13	80-110	14-19	90-125	.....
Dallas	180-220	30-40	150-185	55-70	.....	.....
Stoneville	70-100	54-60	140-200	75-90	200-300	120-125
AVERAGE	118-145	51-61	147-174	64-77	204-252	116-122

¹Office of the Board of Supervising Cotton Examiners.

²Local classing office.

light is not the only factor in determining whether color classing conditions are good or poor. Only for overcast sky conditions in December are the average foot-candle readings highest for "Very Good" classing conditions and lowest for "Poor" classing conditions. For clear and slightly cloudy conditions in both June and December and even for overcast days in June, the highest foot-candle averages are not selected for "Very Good" classing conditions. While the amount of illumination was the only factor measured instrumentally during these tests, later studies corroborated the opinion reported at that time that choice of classing conditions indicates that quality of light may be even more important than amount of light once a minimum amount has been reached. It is quite generally established that color matchers, cotton classers included, prefer light from an overcast or "covered" north sky and it therefore seems probable that the data shown are the result of averaging whatever amounts of illumination happened to be associated with the best liked quality of illumination,

that is, the most favorable energy distribution. Light from a clear blue sky usually was called glaring yet the data show that the amount of illumination on clear days is well below that of slightly cloudy or overcast days.

In 1937 we became actively interested in exploring the possibilities of developing specifications that would provide satisfactory auxiliary lighting units for use in the classification or grading of a number of agricultural products in which color is an important factor. Our early work was with filtered incandescent tungsten, using special glass filters over high wattage tungsten filament lamps in order to filter out the excess energy in the long wave length end of the spectrum of incandescent tungsten to obtain a result as close to the energy distribution of daylight of a lightly or moderately overcast sky as possible. While this study was in progress the fluorescent lamp was announced and in 1939 through the generous cooperation of one of the larger lamp companies a special unit of fluorescent lamps, combining daylight and blue lamps to give adjustable color temperatures, was supplied for this study before fluorescent lamps became generally available for public sale. Early tests on both the filter and fluorescent types were made in three classing rooms, in our own Washington and Memphis classing rooms, and in the Houston classing room of Anderson, Clayton & Co.

It seemed obvious to us that in these tests high color temperatures should be avoided, and our early trials of the installation shown in the next slide were first made with the color temperature of C.I.E. Standard Source C (the international standard for "average daylight") at about 6700K as a goal. But this, as has been reported elsewhere, was found slightly too yellow in color since our classers pronounced conditions "satisfactory" rather than "good" under 6700K conditions. Actually the cottons looked very slightly too yellow under Source C when compared to their appearance under the daylighting conditions which they preferred, and it was necessary to go to a bluer light at 7500K to obtain a minimum color that would give us fully satisfying results. Preference was given to filtered tungsten on the basis of both technical requirements for a daylight substitute and by practical classing tests in all three rooms used in the test.

Later, in a study of the illuminant in textile color matching, measurements were made at color matching stations of several cooperating mills of amount of illumination at the matching surface and of the color temperature of the natural daylight. These measurements, paired with subjective descriptions of the lighting conditions by color matchers on a 5-step scale from "Very Good" to "Very Poor," are illustrated on the next slide (figure 2). As indicated, conditions called "Very Good" required a minimum color temperature close to 7500K for a minimum of 100 foot-candles, although as the foot-candle level increased the accompanying color temperatures decreased. At 100 foot-candles 7500K seems about the minimum for "Very Good"

lighting conditions, but the range extends to include higher color temperature levels. Conditions called "Very Poor" seem to be those which either combine low color temperature with low foot-candles, or those which include very high foot-candles (above 400-500 foot-candles) at any color temperature.

The technical information developed in these studies has been reported to the Illuminating Engineering Society and to the Optical Society of America and published in their journals, the early studies in a series of three papers, 1939-1941, and the later study in two papers, 1948, reported by a committee of the Inter-Society Color Council of which the speaker then was chairman.

On completion of the 1939-1941 studies specifications for artificial daylighting were established to include: Diffuse reflection over a relatively wide area from a wide angle source; color and energy distribution close to that of a moderately overcast sky at 7500K; 60-80 foot-candles on the classing tables. This amount was well above the minimum of what was called "Very Good" for December conditions of natural lighting in our classing rooms, but it was set above the minimum so that even after a considerable reduction in lumen output of lamps there would be enough light for classing. For color work with dark samples it was realized that this specification for amount of light would have to be increased, but we kept our specifications for cotton to a minimum, for in those days it was not known whether it would be practical even to meet this 60-80 foot-candle request--a request that is very modest by 1956 standards!

As a result of these tests, units of artificial daylight made in the form of 4-foot cotton classing skylights, each equipped with six 1,000 watt tungsten filament lamps over each of which was placed a Macbeth filter of Corning's No. 5900 Daylite glass, were installed beginning in 1941 in many classing rooms of the Cotton Division. Their use was no more than spasmodic, for while a majority of classers seemed to feel that they could class satisfactorily under artificial light, the small area illuminated by single units was generally discouraging. Moreover, the use of the natural daylight skylight had become so much a symbol of the trade that for the most part this feeling initially hampered the use of artificial daylighting units. Our Lubbock office, with four units hung in a Quonset hut at the Texas Technological Institute, began to make real use of the artificial lighting, and a few commercial firms began to make similar installations. One such pioneer installation was made by T. D. Truluck of the Deering Milliken Mills in Union, S. C., not far from here.

Then came World War II. It was not easy to find space, nor to build new classing rooms with daylight skylights. So gradually there began a definite and increasing trend to class cotton under artificial daylighting, particularly by commercial concerns. In some cases it proved so satisfactory that skylights were covered or removed entirely. By December of 1949 more than 15 firms in Memphis, Tennessee, alone

were using artificial lighting for much, and sometimes all of their classing. Until 1950 practically all installations were of the filtered tungsten type. However, the initial cost and the inefficiency of the unit which resulted in excess heat and high operational upkeep, particularly when lighting whole rooms, placed it beyond the reach of the majority of users except for auxiliary purposes. Nevertheless, its superior technical qualifications were proved satisfactory in practice, and the cotton industry became convinced that it was an advantage to class under the uniform light of installed artificial daylighting. They were now ready to look around to find a less expensive substitute for filtered daylighting!

Development of fluorescent-plus-tungsten filament lighting

Our offices in Memphis began to try out installations of luminous-indirect and louvered direct-indirect fluorescent luminaires. Most of them provided so much better amount and diffusion of light than the cotton man expected that he began to realize how practical artificial lighting might be. In fact, it looked so good to him in the beginning that he often overlooked the importance of factors such as color quality of the light or the maintenance problem that precludes the use of open fixtures in the extreme dust-catching conditions of cotton classing rooms.

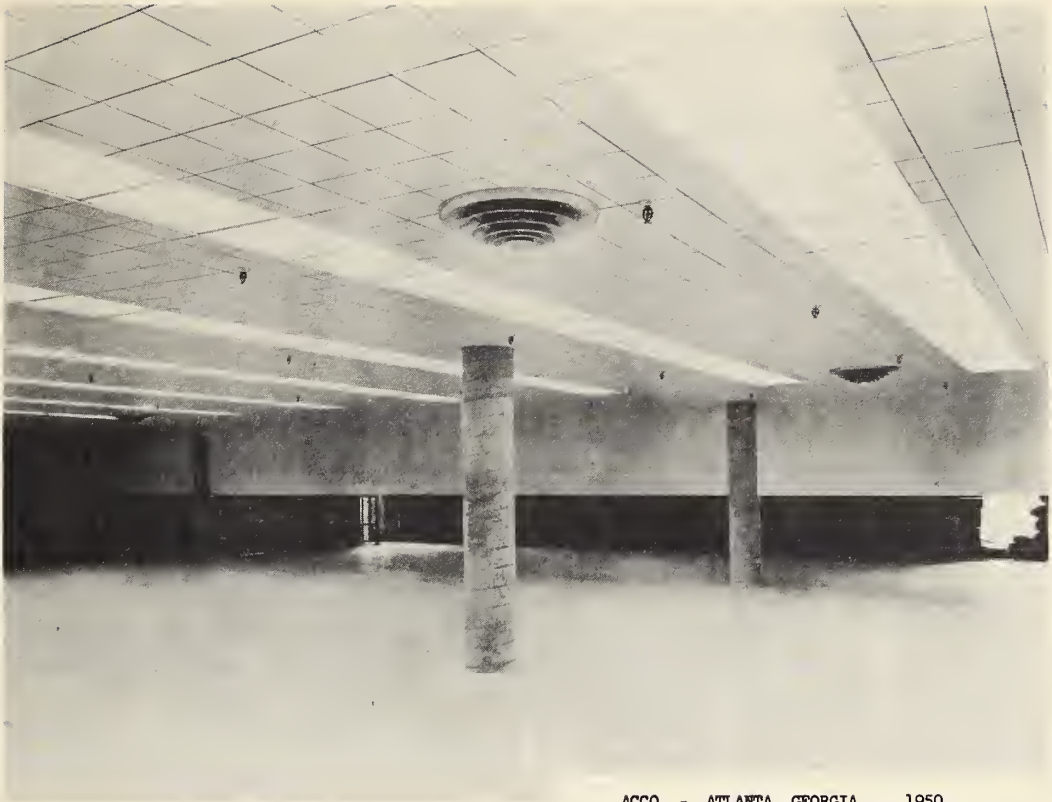
Credit for installation of the first large-scale classing room using Examolites must go to Anderson, Clayton & Company's Atlanta office. There Mr. George A. Levy, in charge of constructing a new classing room at Atlanta, decided to make his own tests. If a suitable way of providing artificial lighting employing fluorescent lamps could be found he was willing to try it out on a fairly large scale in their proposed 70 by 80 foot classing room. A temporary series of different types of fluorescent units were installed and used, and the combination found best was one of daylight fluorescent lamps to which blue fluorescent lamps were added, with white paper used to reflect and mix the illumination until a suitable combination was found at the classing surface. The manufacturer who had installed all of the filtered type of artificial lighting for cotton classing called Mr. Levy's attention to an enclosed examining unit which contained the same sort of combination of daylight and blue fluorescent tubes, but with tungsten added to take care of a lack of red energy in the fluorescent tubes. The original of this examolite had several 50-100-150 watt tungsten lamps arranged so that different amounts of tungsten could be switched into the combination at will. The combination finally selected was three 40-watt daylight fluorescent lamps, two 20-watt blue fluorescent lamps, and four 25-watt tungsten filament lamps. Based on spectral energy curves of the combined lamps it was found that the correlated color temperature produced by this combination was very close to 7500K. Trial installations were made on a number of patterns with units hung six feet above the classing tables

on 8, 9, and 10-foot centers. The results--which confirmed calculated data--indicated that when units were hung at six feet above the table they should be in rows centered no more than 8 feet apart in order to supply reasonably even illumination at table height. On the basis of these trials, the units in the new classing room installation were hung on 8-foot centers, nine feet from the floor. The results were so successful that all thought of providing an auxiliary natural skylight for buyers who might prefer natural daylighting was abandoned. A picture of this early installation is shown in the next slide (figure 3). Directly under the lamps, except at the ends of the rows, there was a foot-candle level of 80 when the writer measured it some time after installation, and halfway between rows the lighting level nowhere fell below 70 at table height.

Since that day when Anderson, Clayton's Atlanta classing room was completed--only about six years ago--much has happened.

In December 1950, Frank C. McClendon of our Dallas office prepared a report for the information of our USDA offices on the use of artificial lighting for classing rooms as it stood at that time. He reported first-hand inspection of twelve different installations by commercial concerns scattered from the Carolinas to Texas, in each of which practically all of the classification was being done under artificial lighting. At that time more classing rooms probably were equipped with the filter type of artificial daylighting than with the examolite type. The next slide (figure 4) provides an illustration of a large and very good type of filtered artificial daylight installation at Cannon Mills in Kannapolis, N. C. However, most of the installations visited were of the examolite type for as Mr. McClendon explained, "while these (filter-type) units have an advantage over the fluorescent units of more nearly meeting the spectral energy distribution requirements for an artificial daylighting at 7500K, they are so much more expensive that we have not considered them in planning lighting installations for entire classing rooms." He went on to report that practically every type of working condition was present in the installations visited and even the ones with poor environment had satisfactory illumination for classing. He reported, too, that of the firms visited, practically all had come up with the same findings as to amount of illumination and spacing of units, but that there was some difference of opinion as to color treatment of surrounding conditions. Since there is considerable shifting of classers within the Cotton Division's offices the report strongly recommended that all of our installations should be as near uniform as possible. The report provided detailed descriptions of each installation visited and included recommendations and purchase specifications for any subsequent purchases by the Cotton Division.

Gradually, as new offices were built, or as moves had to be made to new quarters, several of our classing rooms began to be equipped fully with artificial lighting by use of examolites. There was much



ACCO - ATLANTA, GEORGIA 1950
First large-scale Examolite Installation

Figure 3.



54-FOOT FILTER-TYPE ARTIFICIAL DAYLIGHTING INSTALLATION 1950

Figure 4.

initial grumbling, for most classers felt sure that they would not like such lighting. But working under them convinced even our most conservative classers. I believe it is safe to say that today no one in the cotton business in this country would think of lighting a new classing room with anything but artificial lighting. Typical of this is the fact that in April 1953, the Atlantic Cotton Association at its Thirtieth Annual Convention in Savannah adopted a resolution suggesting to the United States Department of Agriculture that in order to "help insure more uniform classification throughout the classing season regardless of weather conditions and other interferences they (the United States Department of Agriculture) consider.....installing in their cotton classing rooms throughout the cotton belt, modern classing lights." The resolution was incorporated in the report of the Association's Grade and Staple Standards Committee, N. D. Darden, chairman, and "was unanimously adopted."

In the matter of installations it cannot be said that the government led the way. We did assemble in our laboratories the basic technical information that was necessary to establish specifications which practically all of the early installations followed, but after the experience of our laboratory with the poor reception by our own offices of the filter-type lighting we recommended (which afterwards was found successful, though expensive, by a very considerable number of early users of artificial lighting) we, in the laboratory, were rather inclined to hold back until our classing offices themselves began to ask for this new lighting. This they have now done, as is indicated by the summary in table 3 of the lighting situation in classing offices of the Cotton Division existing, or in process, January 1956. Thirty-five of our thirty-seven classing rooms are equipped, or will be this year, with artificial lighting. 1/ A number of these rooms are illustrated in the next few slides (figures 5 to 8). Note arrangement of tables at right angles to lighting in the Greenwood office, and parallel to lighting in the Little Rock office.

The next slides illustrate a few non-government installations, the first, one of many large and busy commercial classing rooms in Memphis, the Bakersfield classing room of the California Cooperative Association (figure 9), the classing room in Italy of the Milan Arbitration Board (figure 10), and an experimental classing room set up by Great Britain's Raw Cotton Commission in Liverpool. Use of artificial lighting is just beginning in countries outside of the United States, so that the Milan installation, and a number of other small ones in Europe, in South America, and in Japan, may be said to be pioneers.

1/ In Washington, where International Grade Conferences are held, both artificial and naturally daylighted classing rooms are available. Since European delegates to these conferences are not accustomed as yet to exclusive use of artificial lighting, the large daylighted classing room has until now been kept as it is.

Table 3.-Lighting in classing offices of Cotton Division, A.M.S., existing or in process January 1956

Office	Location	Approx. dimensions square feet	Usable No. of Examolites			Table Pos. R or P	Date installed, or target	Notes
			Rows	Per Total	No. at peak			
A. SOUTHEAST AREA								
Atlanta, Ga.	1020 Crescent Ave.	N.W. 38 x 63 1/2	4	13	52	R	April 1956	Under construction
Augusta, Ga.	(Corner Druid Park & Wrightsboro Road	38 x 52	4	10	40	R	July 1956	Bids received
Birmingham, Ala.	2628 Millwood Ave.	38 x 64	4	13	52	R	Aug. 1956	Plans in process
Columbia, S. C.	702 Madison Ave.	40 x 53	4	13	52	R	Dec. 1955	
Montgomery, Ala.	Caswell Square	58 x 84	—	skylight	7	R	July 1953	
Raleigh, N. C.	12th & C Sts. S.W.	40 x 38	4	8	33	P	Aug. 1951	
B. SOUTHCENTRAL AREA								
Alexandria, La.	City Park	31 x 44	2	10	20	R	May 1952	Under construction
Blytheville, Ark.	500 W. Chickasawba St.	32 x 65	4	13	52	R	May 1956	
Greenwood Miss.	405 W. Market St.	35 x 70	4	14	56	R	July 1955	
Hattiesburg, Miss.	East Seventh St.	16 x 26	4	4	8	R	Aug. 1954	Seasonal office *
Hayti, Mo.	108 S. 3rd St.	48 x 50	6	10	60	R	July 1954	
Jackson, Miss.	220 W. Pascagoula St.	32 x 53	4	11	44	P	Jan. 1955	
Little Rock, Ark.	210 Gaines St.	35 x 70	4	14	56	P	Aug. 1955	
Memphis, Tenn.	1328 Monroe Ave.	80 1/2 x 38	4	17	68	R	Oct. 1952	Area classing office
Memphis - BSCE 5/	1328 Monroe Ave.	60 1/2 x 38	4	13	52	P	Oct. 1952	
New Orleans, La.	U. S. Custom House	20 x 44	2	9	18	R	July 1955	
Prentiss, Miss.	Prentiss, Miss.	13 x 24	2	4	8	R	Aug. 1954	Seasonal office *
Winnsboro, La.	802 Adams St.	40 x 49	4	8	32	R	Aug. 1952	
D. SOUTHWEST AREA								
Abilene, Texas		32 x 61	4	10	40	P	June 1956	Plans in process
Altus, Texas		49 x 53	6	10	60	P	July 1951	
Austin, Texas	325 W. Commerce	32 x 61	4	10	40	P	July 1956	Plans in process
Corpus Christi, Tex.	218 S. Staples St.	39 x 49	4	10	40	P	June 1955	
Dallas, Texas	1907 Ross Ave.	49 x 50	6	10	60	P	July 1955	
Galveston, Tex.	701 P.O. Bldg.	27 x 58	3	10	30	P	July 1954	
Harlingen, Tex.	706 North H St.	32 x 49	3	10	30	P	June 1955	Seasonal office
Houston, Texas	600 Texas Ave.	34 x 56	9	13	117	P	Jan. 1951	Present space
Lubbock, Texas	2414 Avenue E	64 x 77	4	21	84	P	Sept 1956	Plans in process
"		83 x 88	10	21	210	R	July 1954	
Oklahoma City, Okla.	408 Northwest Fifth	30 x 49	4	10	40	P	Sept 1955	Seasonal office *
Waco, Texas	Highway 6 - Marlin Rd.	26 x 41	2	4	8	P		
S. WESTERN AREA								
Bakersfield, Calif.	430 - 27th St.	90 x 100	8	9	72	R	Sept 1951	
Carlsbad, N.M.	105 W. Canal St.	50 x 90	4	7	28	R	Sept 1953	
El Centro, Calif.	690 Broadway	29 x 55	3	9	27	R	July 1954	
El Paso, Texas	517 U. S. Courthouse	36 x 47	4	10	40	R	Aug. 1954	For Upland cotton
"	"	20 x 64	2	5	10	P	Aug. 1948	BSCE, supervision
"	"	20 x 20	1	2	2	P	Aug. 1954	For Am. Egyptian Cotton
Fresno, Calif	3533 E. Tulare	64 x 124	4	13	52	R	Aug. 1953	
Pecos, Texas	510 East Third St.	38 x 42	4	13	52	R	Sept 1953	Seasonal office *
Phoenix, Ariz.	304 W. Indian School Rd.	50 x 62	3	6	30	R		
			—	skylight	—			

1/ P = Tables set parallel under lighting units; R = Tables set at right angles. 2/ One row with 9 units.

3/ Room used for preparation of standards. 4/ Additional classing is done in building of Staple Co-op. Assoc.

5/ Board of Supervising Cotton Examiners. Classing room used for supervision samples.



USDA - MONTGOMERY, ALA. 1953

Figure 5.



USDA - GREENWOOD, MISS. 1955

Figure 6.



USDA - LITTLE ROCK, ARK. 1955

Figure 7.



USDA - BAKERSFIELD, CALIF. 1951

Figure 8.



CALIFORNIA COTTON COOPERATIVE ASSN. 1953

Figure 9.



MILAN, ITALY - ARBITRATION ROOM 1953
Assn. Cotoniera Italiana

Figure 10.

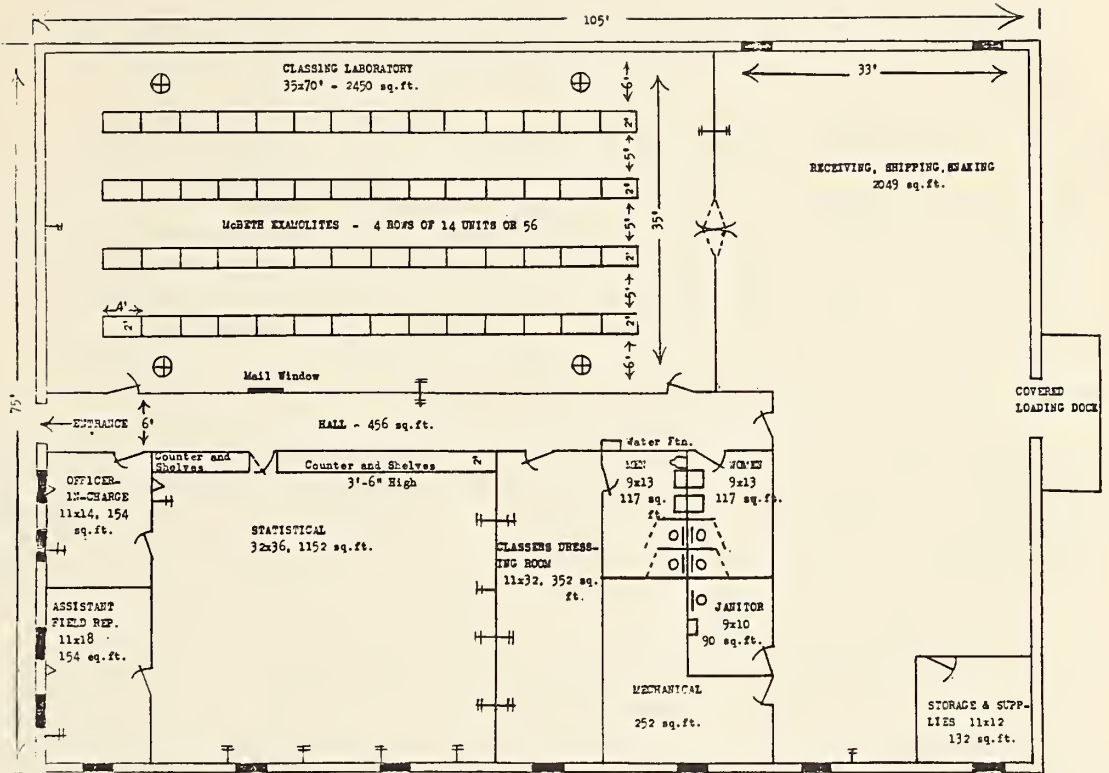
Uniform lighting in classing rooms all over this country, even over the world, would be a big step toward uniform classification. But uniformity in lighting can only be had if such installations follow the same general specifications. Lamps abroad are not the same as ours, and care should be taken to see that technically the overall result meets the same specifications for quality as well as quantity of lighting. Otherwise it is quite conceivable that we could have variation in lighting by use of such a variety of light sources and their combinations that we could be as bad, or even worse off, than by lighting differences in daylighted classing rooms. Unfortunately, the advantages of standardization were foreseen in the beginning by some of the larger cotton firms as well as by the United States Department of Agriculture, and as a result practically all large installations in this country have followed the same general specifications.

Development and Improvement of Specifications, 1950-1956

Developments and improvements have been made in these specifications in the past five years, with a more efficient diffusing glass, a single new examolite tube that combines in one tube the fluorescent colors that formerly had to be obtained by use of both "daylight" and "blue" fluorescent tubes, an improvement that allows use of four tubes of the same size instead of a combination of two sizes as in the early units. Improvement in use of tungsten lamps that will provide very similar color of light but will last many times longer is now under way, for it has been a constant annoyance to have to replace tungsten lamps many times oftener than fluorescent lamps. (Fluorescent lamps have a rated life of 7,500 hours while small tungsten lamps are closer to 700 hours.) There has been improvement also in the specifications for placing the lamp units, moving them up a foot higher (10') and placing them in rows that are on centers a foot closer (7'). This means that no longer is there difficulty in meeting the 60-80 foot-candle requirements, for these newer installations measure close to 100-110 foot-candles on installation. Since the lumen output of the lamps will decrease as much as 30 per cent during its rated life, this means that even with lamps that have burned several thousand hours, providing the tungsten lamps are kept renewed, the illumination level should meet the requirements of the specification.

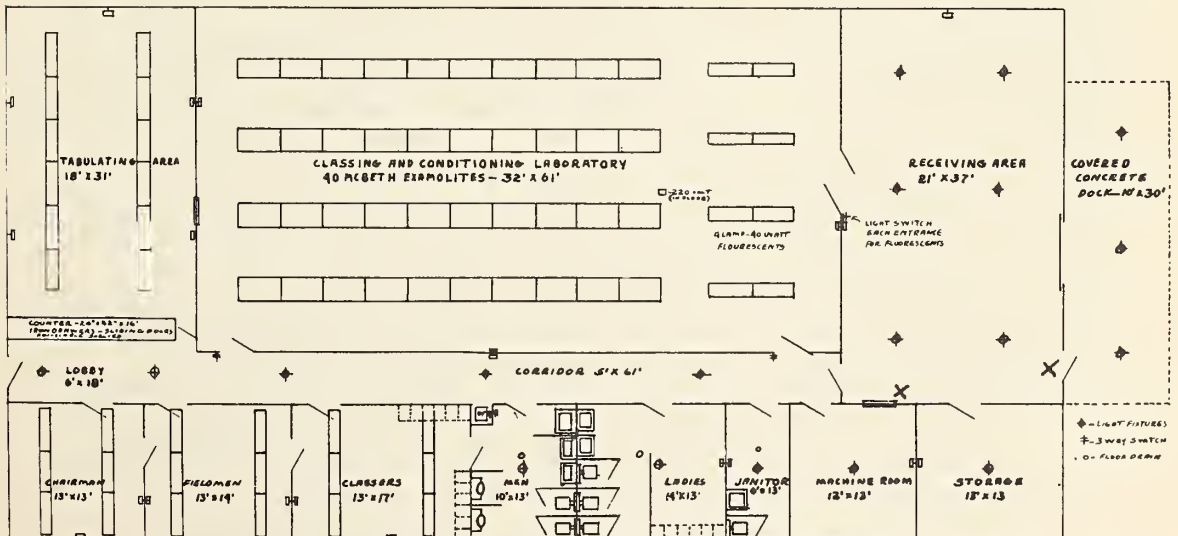
Specifications used at the present time for purchase of lighting units for use in cotton classing rooms of the United States Department of Agriculture are included in Appendix A, page 28.

As regards specification for the pattern to be used within a classing room for installation of units, this is gradually settling down to a fairly definite plan. Slides are shown (figures 11, 12, 13, and 14) for layouts for several different sized or shaped classing rooms, complete with receiving, shipping, and office space. All units are now set 10 feet from the floor, in rows on 7-foot centers. When working under natural skylights classers became used to working



PLAN OF LITTLE ROCK, ARKANSAS, CLASSING OFFICE, SOUTH CENTRAL AREA OF COTTON DIVISION

Figure 13.



PLAN FOR COTTON CLASSING OFFICES FOUND ADAPTABLE FOR SOUTHWESTERN AREA OFFICES OF COTTON DIVISION

Figure 14.

at tables set parallel to the direction of the skylight, and this is necessary also for the filtered incandescent type installations which usually are installed in single rows. But with examolite units the entire room can be lighted, and if this is done uniformly enough over the whole room it should make no difference how tables are placed.

An efficient general plan for our offices is illustrated in figure 14, a sketch for Abilene, which is the same as that used for Oklahoma City, Corpus Christi, Harlingen, and new space for our Austin and Lubbock offices. Our Southwest Area office advises that they have found it very good for their area. It lends itself easily to increase or decrease and can be reversed if property locations restrict its present arrangements. Lubbock, for example, has been increased to 17,500 square feet on this identical plan. (They also point out that the two places marked with a cross, while they seem to be minor, have proven extremely valuable. The single door for ordinary traffic from the receiving room to the outside and the location of the return air and automatic roll type filter in the receiving room rather than in the hall, eliminate a tremendous quantity of lint that accumulates in the hall where the return air is through the hall or corridor.)

For a single table no less than three units, set end-to-end, should be used. The minimum specification for lighting a small room is two rows of four units each. A plan for such a room is illustrated in figure 11. Larger installations provide better conditions for it is easy to see that the longer the rows, the more good classing space there will be available, since the light under the ends of each row, and under the end row of lamps, is less than that in the remainder of a completely illuminated room. An even number of rows, preferably a minimum of four for an average sized room, increasing to six, eight, or ten for larger rooms, allows efficient use of space for tables such as are used in our offices. They can be placed either parallel to the direction of the lighting, or at right angles. When at right angles under four rows, one row of tables is placed so that one end of each is under row 2 of the lamps, the tables extending back to row 1, and another row of tables is placed so that one end of each is under row 3 of the lamps. The classer stands at the head of his table, one at row 2, the other at row 3. As he looks along his table the lighting will be quite uniform as far as the center of the row of lighting over the far end of his table, beyond that it will fall off unless there is an additional row of lighting. With tables set at right angles to the lighting, it takes two rows to light his table adequately, and then it will light it uniformly only for the 7-foot distance between centers of the rows of lighting. Refer to figures 1, 4, 7, 9, and 10 for tables set parallel, and to figures 5, 6, and 8 for tables set at right angles to lighting.

It should be pointed out that for these large installations, air conditioning is specified along with the lighting.

Color of Surrounding Conditions Important in Lighting Installations

The color of walls, ceilings, floors, furniture, and even of the product itself (if it covers a large area when laid out for classing) has a considerable effect on the lighting in a room. There is an effect on both the physical amount of light reflected, and on the psychophysical effect of what illuminating engineers call "brightness contrast." Since there is a considerable shifting of classers from one office to another in the Cotton Division, especially during the peak of each classing season, it is important that conditions in all Government installations be kept as uniform as possible, not only with regard to the type of installation, but in the surrounding conditions also.

Classing rooms should be painted a neutral color so that no one chromatic color, whether of cotton or of any other product, will be flattered or discounted more than another. Neutral colors may be light or dark, from white through a series of light to dark neutral grays, on to black. The lightness, or the reflectance of the gray that should be used in any room depends on the amount of light coming into it and reaching the classing surface. In rooms lighted by natural daylight the wall and ceiling color can be a lighter gray for rooms with a small skylight, or those not too well lighted by window space, than for rooms into which a great deal of light enters, as from an 80-foot skylight. When there may be an excess of light the gray wall color, especially the color of the upper wall facing the skylight, may be a gray as dark as Munsell N 6/. This is because there is sometimes so much light from a large skylight (in June, for example) that the light would be glaring, and produce glaring contrasts if it were not reduced by a fairly dark color on the wall. The darker the gray on the walls, the more the light falling on that wall will be absorbed. Conversely, rooms where there is only a moderate amount of light should have walls painted a light gray so that more of the light can be reflected back into the room.

For rooms with artificial lighting, such as those lighted with wall-to-wall examolites, the surroundings should be light (near-white) in color in order to conserve the lighting and to reduce brightness contrasts as much as possible. The following specifications are those which we use:

Walls, preferably Munsell Neutral 8.5/, certainly not darker than Munsell Neutral 8.0/;

Ceilings, white or as near white as possible, certainly not darker than Munsell Neutral 8.5/;

Floors, preferably a light gray, about Munsell Neutral 7.0/ (although darker floors may be satisfactory);

Mats, on which a classer stands, should be black (so they may be used as a background for stapling);

Tables for classing, black, although gray may be satisfactory.

(When in use tables are covered with white cotton which keeps the light reflectance high during periods of use.)

The color of the grays above is specified in Munsell color notation by reference to the Munsell Value Scale. For those not acquainted with this notation, an inexpensive scale in 18 steps of neutral gray, may be obtained from the Munsell Color Company, Inc., 10 East Franklin Street, Baltimore 2, Md. We supply such scales to our own USDA cotton classing offices, with a copy of these recommendations. The address is given so that others may obtain a copy, unless they find the following description sufficient for their purposes:

The Munsell Neutral Value Scale consists of a series of neutral grays in visually equal steps from Black (at 0/) to White (at 10/). Munsell Neutral 7.0/ designates a light gray, 8.0/ and 8.5/ designate increasingly lighter grays, 9.5/ is a very good white.

The grays used in the classing room should be neutral grays, showing no trace of any hue; that is, they should not be yellowish grays, greenish grays, or bluish grays.

We might note also that at least one paint company (in Dallas) has produced a flat wall paint to meet the N 8.5/ specification, calling this color a "Cotton Grading Gray."

Maintenance of Lighting Equipment

One of the things that must be impressed upon users of installed lighting is that lamps and equipment must be properly maintained in order to hold the proper level of lighting. It is not enough to install good lighting; it must be maintained. Otherwise we shall not long continue to have uniform lighting conditions in the various offices in which our cotton is classed. We quote at this point suggestions for maintenance taken from "Housekeeping Hints for Classing Offices" prepared last spring by Frank C. McClendon of our Southwest Area office.

The proper maintenance of the classing lights is essential to adequate lighting. Your lighting troubles are not solved merely by the installation of Examolites. Any electrical or mechanical device needs attention and preventative maintenance has proven to be the least expensive. Due to varying word loads, weather conditions and the periods of time the classing lights are used it is not practical with the information at hand to definitely set up a maintenance schedule. However, each office should effect their own schedule and keep some type of record on maintenance and designate one individual to be responsible for this activity.

The following suggestions are offered:

1. Daily inspection.

- (a) Immediately upon turning the lights on a quick visual inspection should be made to see if all tubes and bulbs in each unit are burning. Perhaps it would be well for the classer to assume this responsibility for the lights in his area as soon as he goes to his table.
- (b) Once or twice during the day another check should be made for burned out tubes and lamps.

2. Replacement of Tubes and Lamps.

- (a) The expected life of the fluorescent tube is from 7,000 to 7,500 hours or approximately three seasons' use. The 25-watt incandescent lamp is 700 hours, but this may vary if current fluctuates considerably (a new longer life lamp is now under investigation as a substitute for this tungsten incandescent lamp.)
- (b) Tubes found flickering or lamps burned out should be replaced immediately.
- (c) Use the proper type of tube or lamp for replacement.
- (d) Chart your classing lights and indicate on each light the initial date of installation, the foot-candle reading and date of tube replacement. One season's record of this type will give you a working base that may be used as a guide for replacements. More than one season will be required to set up a definite replacement schedule. An elaborate record is not intended but only a notebook record at the time a tube is replaced. There is some doubt as to the necessity of keeping a detailed record on each unit. Certainly it should not be a burden.
- (e) Foot-candle readings should be charted or recorded at the beginning of the season and at least weekly readings should be made throughout the season to determine the light intensity.
- (f) Lumen output of lamps declines as the life expectancy is approached and when tubes reach a 30% decline from the original reading they should be replaced. Readings should be taken at the time of installation, and before and after washing, in order to have a base from which to figure the natural decline.

3. Cleaning the Fixtures.

- (a) Tight construction prevents an over amount of dust collecting but some dust does collect in the more dusty areas.
 - (b) Cleaning both the inside of the unit and the glass thoroughly at the beginning of the season and periodic inspection should determine how often the unit should be washed completely.
 - (c) Inside of unit and the glass should be washed with a wet cloth, thoroughly dried and left sparkling. Do not just wipe out. Water used in washing should be changed often and rags should be rinsed out frequently
 - (d) A weak ammonia solution should be adequate.
 - (e) Occasionally, when there has been an unusual amount of dust, under side of glass may be vacuumed and then wiped off with a wet rag and thoroughly dried. Do not smear as a streaked glass can cause light irregularities.
 - (f) The outside of hanging fixtures should be vacuumed before cleaning the glass.
4. The upper plates inside the mixing chamber should be removed and the ballasts inspected once per season. Low voltage tends to cause ballasts to overheat and bleed. The resulting melted asphalt will run down inside the unit.
5. It is not intended that the care of the lights should be a burden, but periodic inspections and cleaning are necessary to maintain the lights at adequate intensity and in the best operating condition.

Spectral Energy Distribution Basic to Color Grading

There is one very important matter that should be called to the attention of a group such as this. This relates to the importance of the spectral energy distribution of lighting to be used in color work. For cotton we have found that the combination of fluorescent and incandescent lighting described is quite satisfactory for classing the colors of cottons, most cottons being near-white. It does not follow that it will be equally successful for all agricultural products, nor that it will serve all purposes. It may be entirely satisfactory for inspecting or sorting purposes, but unsatisfactory for initial grading of a product.

My own work in lighting has been chiefly with its technical color phases, the details of which are not easy to explain. Indeed, few lighting engineers are acquainted with the spectral energy requirements for color grading and inspection work. Because we have such a variety of new light sources the problem becomes even more complicated. For example, there are on sale today, in addition to special lamps, five different white fluorescent lamps made regularly by practically all large lamp manufacturers: two Warm Whites, two Cool Whites, and a Daylight white. The Warm Whites are yellowish, at a color temperature near 3500K; the Cool Whites are whiter, at a color temperature near 4500K; and the Daylight white is about 6500K, the color of average daylight. The Warm and Cool Whites come in a Standard lamp, which places emphasis on high lumen output, and in a DeLuxe lamp, in which the emphasis is on better color rendition.

The fact that there is a pair of Warm and a pair of Cool Whites illustrates my point about spectral distribution. The color of each pair of these lamps is about the same; they look alike; one cannot tell them apart by looking at a pair of lighted lamps. However, the spectral energy distribution, although it may average to the same color for each pair, is quite different in some parts of the spectrum. The next slide (figure 15) illustrates this; the DeLuxe lamps clearly show more energy in the red end of the spectrum than the Standard lamps. And this means that for many products the color will appear different under the Standard lamp than it will under the DeLuxe lamp of the same color. The amount of color shift in a sample will depend on its own capacity to absorb and reflect the different wave lengths of the spectral energy that may fall upon it. For cottons, shown in the next slide (figure 16), the curves are smooth and regular, with no evidence of distinctive absorption bands which may be present in other products.

I do not expect here to give you a lesson in these matters. There is not time. But their importance is so great to any real understanding of what should be expected of lighting for color grading that I do wish to give you at least some insight into the problem.

First, what are we after in lighting for color grading?

Usually, for grading of agricultural products, we are after lighting under which products will appear the same as they would under that type of daylight which is usual or preferred for grading the product. If the product is graded in sunlight, then a satisfactory substitute illumination should have the same relative energy distribution, wave length by wave length, as there is in sunlight; if, as is more usual, a product is graded in a north window or under a north skylight, with preference for a lightly or moderately overcast sky, then a satisfactory substitute illumination should have the same relative energy distribution as that of a lightly overcast sky from the north.

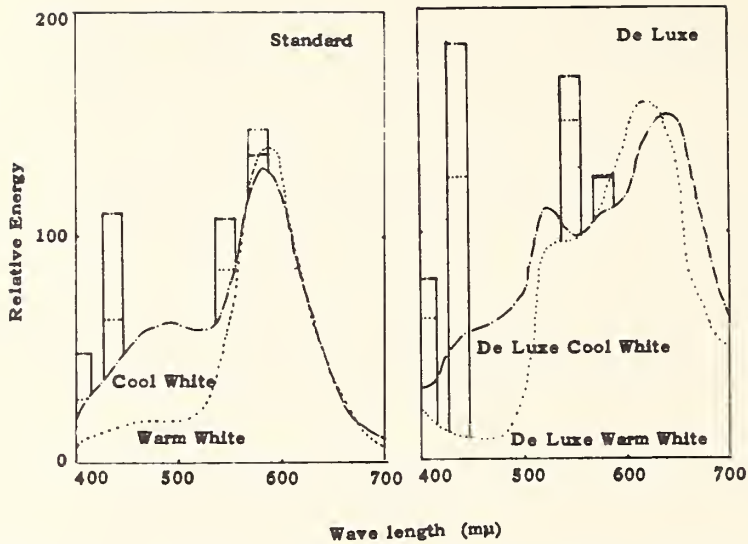


Figure 15.--Typical relative energy curves of two sets of fluorescent lamps. One set is Standard, with maximum lumen efficiency, the other is De Luxe, with more energy in the long wave length region (red end) of the spectrum to provide better color rendition.

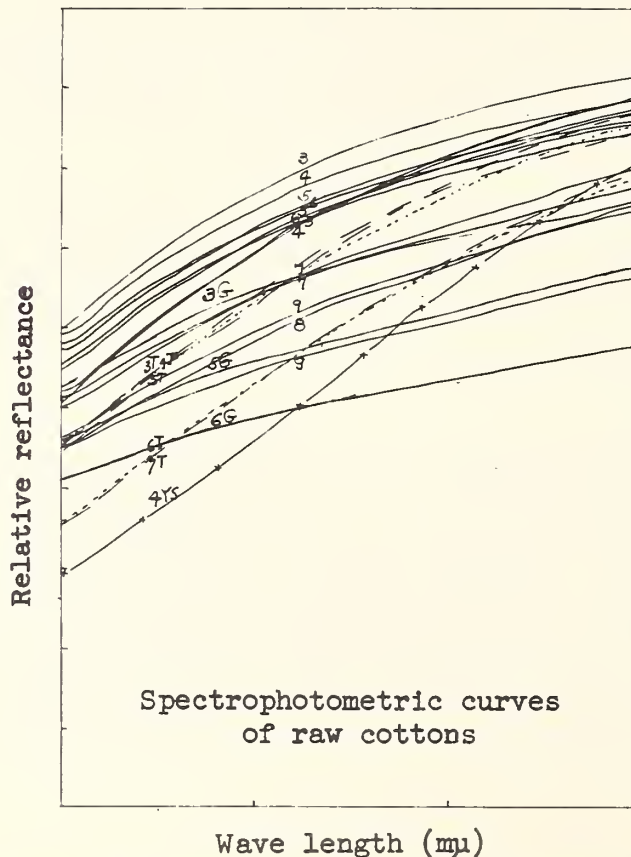


Figure 16.--Spectrophotometric curves for cotton samples, high to low in grade and gray to yellow stained in color class.

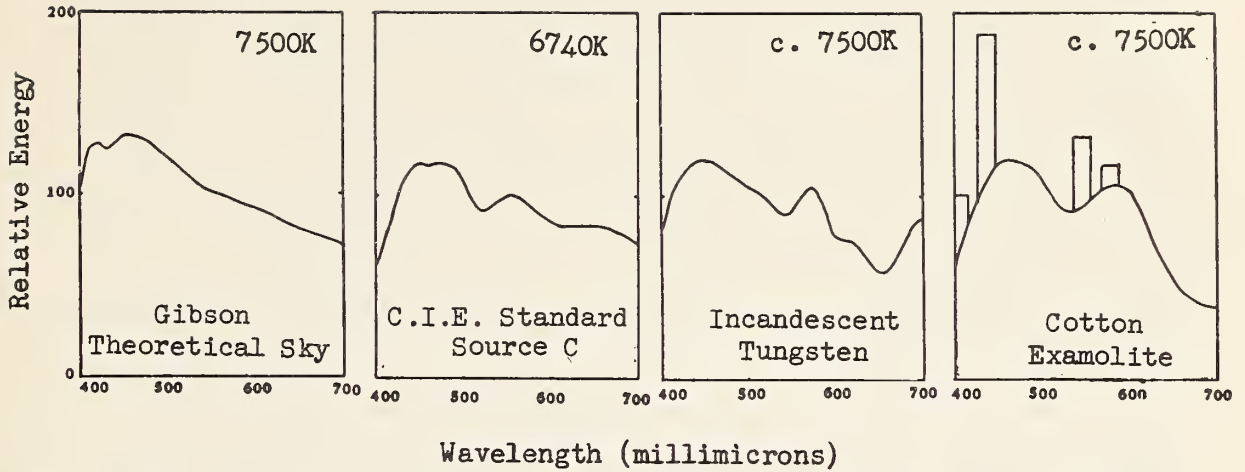


Figure 17. Relative energy curves of theoretical and actual illuminants in the daylight range near to 7500K as recommended for cotton color grading, with the international standard for average daylight—C.I.E. (formerly I.C.I.) illuminant C—shown for comparison and reference.

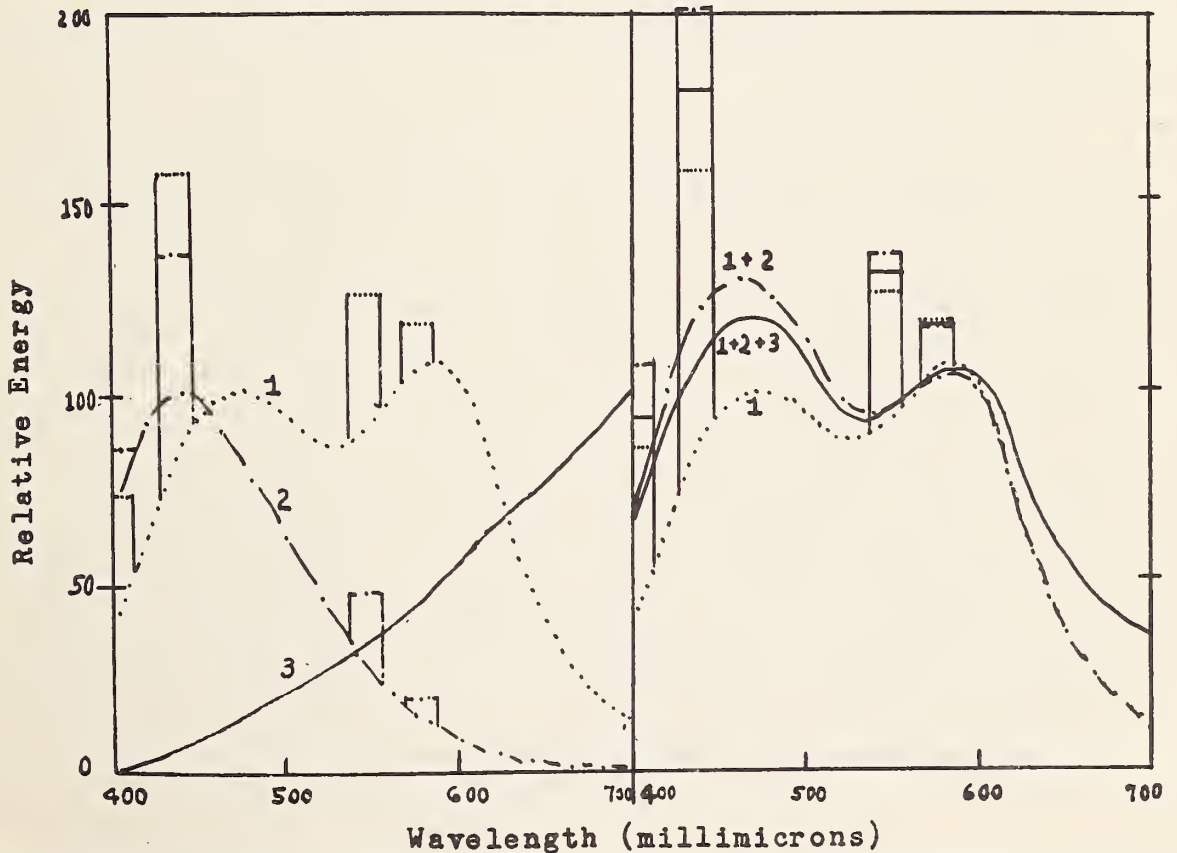


Figure 18. Spectral energy curves of separate and combined lamps used in the cotton examining unit. Curve 1: three 40-watt daylight fluorescent; Curve 2: two 20-watt blue fluorescent; Curve 3: four 25-watt silver-bowl filament lamps.

The next slide (figure 17) shows the relative energy curves of daylight at 7500K and several daylight substitutes. Measured curves of daylight reported by Dr. Abbot of the Smithsonian Institute are used as a basis for the curves marked "Gibson theoretical sky," used as our standard. The C.I.E. curve for Source C, an international standard, is shown for comparison. The curve for filtered incandescent represents the best artificial daylight at 7500K we have been able to attain, and while it does not show as close a reproduction of the daylight curve as we would like, it is almost equally as good as Source C, which is adopted as an international colorimetric standard for average daylight. As for the curve for the cotton Examolite, while it does not appear too close to the 7500K theoretical skylight curve, it is far closer to it than any single fluorescent lamp available today. Compare its curve, for example, to the curve for the daylight fluorescent lamp in the next slide (figure 18) which contains spectral energy curves of the separate and combined lamps used in developing the cotton examining unit. To the daylight curve marked 1 is added the blue of curve marked 2 to make the curve on the right that is marked 1+2. This curve represents the relative spectral energy of the special Examolite fluorescent tubes now manufactured for use in these units. The energy distribution of the 25-watt tungsten filament lamps of the Examolite unit are shown in curve 3. By addition of these lamps the relative amount of red is increased and the blue decreased, as represented in the solid line curve marked 1+2+3. The bars that extend above the curve represent the excess energy of the mercury that activates the fluorescent powders in the fluorescent lamps. These are the "mercury lines."

While it is really the spectral distribution of the illumination that is important in color work, a shorthand description in terms of color temperature often is used to describe the color. At this point it may be well, therefore, to report the most recent information on the color temperature of the new Examolite tube by itself, and the unit complete with regular 25-watt incandescent lamps added, with and without aluminum caps, and the unit complete with the newer incandescent lamps that are designed to last much longer. In a private communication, Mr. Norman Macbeth tells us that they propose to use for this special purpose a gas filled lamp, 40 watts, 130 volts. When operated at 115 volts, as is recommended for the Examolite units, these special incandescent lamps would have a life of over 5,000 hours, with a wattage of 33. C.I.E. (x, y)-data, supplied by Mr. C. W. Jerome of Sylvania's Engineering Laboratories, are the basis for the correlated color temperatures reported in table 4 for these lamps. While the data show that the new incandescent lamp is slightly redder than the present one, an increase in life from less than one to over five thousand hours may offset the importance of this difference. As can be seen, it is really considerably more important to be sure that caps always are used over the incandescent lamps, otherwise the units would really be redder.

Table 4.-Colorimetric data for Examolite fluorescent tube, and for regular and special experimental incandescent lamps.

Lamp, or combination	C.I.E.		Color temperature
	x	y	
Examolite fluorescent tube	0.292	0.314	c.8050K
Examolite tube + regular incandescent lamp, no caps	.307	.323	c.7000K
" " + special " " " "	.310	.324	c.6700K
" " + regular " " with caps	.301	.319	c.7350K
" " + special " " " "	.303	.320	c.7200K

SUMMARY

During the past season the United States Department of Agriculture, in 35 local offices, already has classed over 12.5 million bales of cotton. Visual judgments are the basis for grade and staple determinations of cotton samples: therefore, if classing is to be done uniformly and promptly, the quality and quantity of lighting in a classing room becomes a matter of economic importance.

Natural daylight skylights based on studies that resulted in a "government-type skylight" were used widely from 1914-1937 as a guide by builders and architects designing commercial classing rooms. In the 1930's artificial daylighting studies led to satisfactory units of filtered-incandescent tungsten lighting. These, despite their inefficient use of electric power, were increasingly used by the cotton industry during the 1940's until, by 1949, the cotton man began to lose his long time reluctance to class under anything but daylight.

By 1949-50 many cotton men began to look around for lighting less expensive than the filtered incandescent, and an answer was found by combining in a single unit fluorescent and incandescent lamps to produce a color temperature about 7500K, with a spectral energy distribution as close to that of daylight at 7500K as was possible with these lamps. In the 1950-56 period there has been development and improvement of details, yet the basic specifications remain: Diffuse reflection over a relatively wide area from a wide angle source; color and energy distribution close to that of a moderately overcast sky at 7500K; no less than 60-80 foot-candles on the classing tables. Such substantial achievements have been reached that it is now accepted procedure to supply artificial rather than natural daylighting for classing rooms, and more often than not this is by lighting the entire room. Standard installations employ lighting units set end to end in an even number of rows, the rows on 7-foot centers, with the bottom of units 10 feet from the floor. These may vary from small rooms with two rows of four units each to large rooms with four, six, or even ten or more rows of 10 to 20 units each.

Specifications are provided for lighting units, the color of surrounding conditions, and instructions for maintenance. The importance of spectral quality of lighting and its relation to the product is discussed, and attention called to the corollary that an ideal substitute for daylight is one under which the appearance of samples is the same as under daylight, while a satisfactory substitute is one under which the appearance of samples--their color rendition, or color-difference between samples--is sufficiently duplicated to provide satisfactory grading or inspection. A sound decision as to what is needed involves consideration of the spectral energy distribution of the light source and the spectral reflectance characteristics of the samples, plus a knowledge of inspection and grading practices that apply to the product under study.

While we cannot see any probability of new light sources that will provide in any immediate future practical large-scale lighting with closer spectral energy distribution to daylight than that reported here, nevertheless, it is not impossible that progress in lighting research will one day supply us with such a source. Meanwhile, the answer we have found for cotton will serve equally well for inspection and grading of many other products. When close daylight quality is of prime importance to retain the daylight appearance of any product, the filtered daylight type of lighting may be necessary, but once the psychological adjustment is made toward acceptance of artificial lighting, use of a daylighting substitute may be found less critical for some products than for others. For many products the Examolite type will be satisfactory.

APPENDIX

SPECIFICATIONS FOR LIGHTING UNITS TO BE USED IN COTTON CLASSING ROOMS

TO BE SUPPLIED: Artificial lighting units, each unit to operate with four 40-watt Examolite fluorescent lamps, and four 25-watt incandescent lamps. Lamps to be furnished by bidder. To be in accordance with the following Service Requirements, Specifications and Applicable Conditions.

SERVICE REQUIREMENTS:

The lighting units described herein will be used in the cotton classing laboratories of the Cotton Division, Agricultural Marketing Service, in the classing of cotton samples. For this purpose it is necessary that the units be designed to supply satisfactory amount and color of illuminant over the surface of a classing table when units are placed end to end over the tables, preferably with the bottom of the units 10 feet from the floor, with rows centered 7 feet apart. The units shall be designed to provide an initial illumination on the classing table of no less than 60-80 foot-candles when units are hung as specified, and to provide color and spectral quality as close to that of daylight of a moderately overcast north sky, c.7500K, as is possible in a unit that includes properly designed or especially designed fluorescent lamps. The unit should be suitable for use in a cotton classing room, be easy to maintain in good order and be as light in weight as is practicable.

SPECIFICATIONS:

These units are to be similar or equal to Macbeth Type C4, Cotton Examolite fixtures equipped with Macbeth Examolite fluorescent tubes.

Each unit shall be self contained providing for use of four 40-watt, 48-inch, F40T12-EX fluorescent lamps and four 25-watt* incandescent, inside frosted lamps (A-19 IF). Metal caps shall be supplied for use with the 25-watt incandescent lamps. The unit shall consist of a standard reflector and mixing chamber to combine the light from the several lamps. The four 40-watt Examolite tubes (F40T12-EX) lamps shall be set lengthwise in each unit, and the four 25-watt incandescent lamps shall be set about 11-1/2 inches from the end, 8 inches from the side. The interior shall be finished with a baked white polymerin or other equally good white permanent finish. Ballasts should be rapid start, and of the voltage regulating type. The placement specified is made in order to provide good color mixing. The measurements given are approximate, but should be within a quarter inch tolerance.

Diffusing glass similar or equal to Crista-lite pattern 63-64 (waffle pattern one side, fluted edges on the other side), in panels approximately 2-foot square, shall be used on the bottom to diffuse the light and enclose the unit. The glass must be spectrally neutral (equal in color to Crystalex Plate or Aqua-White). Samples of glass other than Crista-lite, pattern 63-64, must be submitted for color and diffusion tests together with bids. Samples of tubes other than Examolite F40T12-EX, 40-watt size must be submitted with bids. Glass and tubes delivered by successful bidder must be equal to any such samples approved by the U. S. Department of Agriculture when award is made.

The containing box shall be of metal, completely fireproof, approximately 2 feet wide, 4 feet long, not over 14 inches high, with two 3-inch angle brackets on each side of the unit approximately 4 inches from the end. The brackets shall be secured to the unit by one bolt with a nut and lock washer on the inside of the unit to allow for adjustment of the angle of the bracket when hanging. Each bracket shall be drilled with a 5/16" hole for a 1/4" eye bolt.

Each unit shall be designed for operation on 110-120 volt 60 cycle, AC current and wired ready for connection to an electrical plug, with a 6 foot wire. The wire from the electrical connections inside the unit shall be through a 1/2 inch Greenfield connector. Most city electrical codes require a flexible armored cable and nothing smaller than 1/2 inch connectors and cables are used on this size fixture.

*Note discussion (pages 26 and 27) of tests now under way of a longer life substitute for these 25-watt incandescent tungsten lamps.

